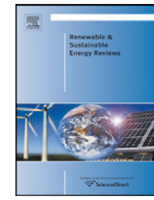
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The inclusion of social aspects in power planning

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ABSTRACT

This paper overviews previous research addressing the inclusion of the, social dimension of sustainable development on power systems planning. Consequences of the recent energy policies and strategies are already being felt in, developed countries' power systems, with the integration of rising quotas in renewable, energy technologies. However, while the tools that aid decision making on power, planning show that economic and environmental issues are easily quantifiable and thus, modeled, social concerns have been addressed in a less extensive and more, subjective way, implying in most cases expert participation on multi-criteria decision aid, techniques. A survey of recent papers providing public perceptions on electricity, generation technologies and projects is presented. These papers were chosen and, reviewed in order to present a representative array of methodologies that are used to, assess social acceptance of technologies. According to some of the reviewed papers, this issue is suggested to be fundamental to increase project success. As a conclusion, stands the fact that further discussion is still needed in order to achieve solid, agreement, among experts, over what are the positive and the negative drivers to, social sustainability; otherwise models will not be able to translate reality and improve it, under this point of view.

Contents

1. Introduction

In 1997, the Kyoto Protocol was adopted. One decade later, the European Union proposed the so-called "20-20-20" package, which goals are (i) to cut in greenhouse gases (GHG) emissions to at least 20% below the 1990 levels, (ii) to reach 20% of renewables' share in the energy mix and (iii) to cut 20% in primary energy consumption, until 2020. The electricity sector is of major importance for the energy decision makers, as it accounts to, roughly 20% of the total energy consumed in the aggregate of the 27 countries of the EU.[1] Also, it still relies mainly on fossil fuel power plants responsible for high GHG emissions. Although some of these older power plants are to be dismantled within the next decades, the consumption of energy is also expected to increase around 15% during this period [1]. Therefore, replacement and instalment of new power plants will take place, hopefully taking into account the social, economic and environmental impacts. In the context of this study, electricity power planning will be perceived as the process of (i) setting goals for the electricity sector, (ii) designing strategies and policies and (iii) decommissioning and building infrastructures in order to achieve the proposed goals.

As a result of the uncertainty involved, with the economic conjuncture playing a major role, the planning of the electricity power system on a long-range term (10 or more years) is an increasingly challenging issue. For example, before the 70's, no big effort was placed on planning. This view substantially changed after the first oil crisis, at the level of searching for efficient supply options, based mainly on cost optimization objectives [2]. Later, in the 80's, as the

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1 Data retrieved from http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction.

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public became aware of environment devastation, decision-makers started to include environmental issues on the models [3]. The generalization of multi-criteria decision analysis (MCDA) methods gave planners the possibility to address other issues such as land use, human health and reliability of the system [4] and allowed for the explicit integration of the social dimension of the decision making process.

Although the literature related to energy often mentions "sustainability" or "sustainable development", few works actually refer to the social aspects of electricity planning. Therefore, this paper aims to present a comprehensive and multidisciplinary review of the recent literature on this theme, focusing on the concept of social sustainability and public perceptions of electricity generation technologies, both within the scope of the social sciences, plus planning and technical analysis, within the borders of engineering.

The remainder of the article is as follows: in chapter 2 the theoretical aspects of social sustainability are reviewed, presenting an overview of how these have been addressed in the literature; in chapter 3 studies aiming at the inclusion of the social impacts of electricity generation are analyzed; chapter 4 presents some of the methodologies most frequently used to assess public acceptance of electricity generation technologies; based on the review of the literature, conclusions are drawn in chapter 5 and guidelines for future research are discussed and proposed.

1.1. Sustainable development and social sustainability

Every citizen of the developed world has been increasingly faced with the expression "sustainable development", whether it happens in the context of climate change, or when one gets conscious that some resources in which we base our society are finite. The most influential definition for sustainable development was presented in the Brundtland Report, where a pattern of resource use is presented that "meets the needs of the present without compromising the ability of future generations"[6].

It is widely accepted that Economy, Environment and Society are the three pillars for sustainable development. However, these pillars are often interconnected in real world situations. It should be reminded that Copenhagen's goals address emissions of GHG, which, although related with social impacts (for example, health), is mainly an environmental aspect. No similar global conference exists proposing such a large scale of goals for social sustainability.

Some definitions of social sustainability are now presented, as well as some related questions posed in the literature, which highlight the special characteristics of the concept.

Black [7] states that social sustainability is the continuation of society in the future, implying the continuation of its social values, social identities, social relationships and social institutions. This concern for the future in the long run has also been expressed on Biart [8], definition: "[Sustainability] aims to determine the minimal social requirements for long-term development (sometimes called critical social capital) and to identify the challenges to the very functioning of society in the long run".

Social sustainability is also underlined by Polese and Stren [9], as a "development (and/or growth) that is compatible with harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population". Sachs [10] states that "sustainability must rest on the basic values of equity and democracy, the latter meant as the effective appropriation of all human rights – political, civil, economic, social and cultural – by all people".

In the perspective of Griessler and Littig [11] social sustainability is achieved "if work within a society and the related institutional arrangements (i) satisfy an extended set of human needs and (ii) are shaped in a way that nature and its reproductive capabilities are preserved over a long period of time and the normative claims of social justice, human dignity and participation are fulfilled". However, the authors also recognize that suggesting "social sustainability indicators that are drawn from sociological theory is one story. To incorporate them into policy-making and to have an impact is another one."

More recently, Colantonio [12] argues that during the 90's there was an emergence of new social concerns. Based on this assumption the author divides the key themes used on approaches to assess social sustainability in two categories:

- *Traditional*. (i) Basic needs, including housing and environmental health, (ii) education and skills, (iii) employment, (iv) equity, (v) human rights and gender, (vi) poverty and (vii) social justice.
- *Emerging*. (i) Demographic change (aging, migration and mobility), (ii) social mixing and cohesion, (iii) identity, sense of place and culture, (iv) empowerment, participation and access, (v) health and safety, (vi) social capital, (vii) well being, happiness and quality of life.

The author argues that social sustainability is gaining recognition as a fundamental dimension of sustainable development. His work also demonstrates that monetization and accounting techniques, which exclude participation, still dominate sustainability tools. He also states that, besides the promotion of social capital, few tools for implementing that concept exist.

Vallance et al. [13] reviewed the literature which refers "social sustainability" in somewhat "chaotic, contradictory and confusing" ways. Therefore, the authors took all the approaches to the "social sustainability" concept they could find in the literature, and group them according to the three following strands: (i) development, including literature focusing on the need to meet more or less tangible basic requirements and needs (ii) maintenance, referring to papers mainly associated to the peoples preferences on the preservation of socio-cultural characteristics and (iii) bridging, based on literature addressing ways of involving people on the environmental goals and compromises.

Besides the array of definitions, the literature also addresses some inconsistencies, which arise from these ones. For example Murray et al. [14], raised the questions: "how long something must persist for it to be called sustainable?" "and who's counting?". McKenzie [15] points also concerns with cultural issues as a basis for achieving social sustainability; and presents a feature of a social sustainable society: "a system of cultural relations in which the positive aspects of disparate cultures are valued and protected, and in which cultural integration is supported and promoted when it is desired by individuals and groups". The following question might be asked: is it possible to achieve overall agreement on which are the positive aspects of disparate cultures, in a multicultural society?

As stated in [16] most of the sustainable development discourse has always been focused on environmental sustainability. The same study criticized the Brundtland Report as being too narrow on social aspects, making them coincide with poverty. According to Benaim et al. [17] "the social dimension seems overwhelming. Unlike the environmental and economic systems where flows and cycles are easily observable, the dynamics within the social system are highly intangible and not easily modeled." Plus, as underlined by K: Missimer et al. [18] the researcher is part of the social system and as so he cannot observe as an outsider.

These arguments clearly bring the problem of knowledge on social sustainability at a distinct level of the knowledge on ecosystems or climatology, where the scientific community can achieve a certain level of agreement, constructing somewhat robust models for forecasting impacts.

Table 1
Survey of papers addressing social concerns in power systems decision-making.

Reference	Methodology which led impacts to be considered	Number of social impacts considered	Study objectives	Subsequent models and methods (application of the impacts as criteria / indicators)
Kowalski, Stagl et al. 2009 [19]	Interviews with Energy experts, community councilors, NGO's. Scenario building	5	Comparison of RES technologies	MCDA (PROMETHEE)
Kahraman and Kaya [20]	Literature review	4	Comparison of RES technologies	MCDA (Fuzzy AHP)
Karakosta et al. [21]	Collection of official indicators	2	Evaluation of energy policy guidelines	SWOT Analysis
Roth et al. [22]	Collection of official indicators	6	Comparison of energy technologies	MCDA
Gamboa and Munda [23]	Interviews, including environmentalists, governmental and industrial stakeholders	6	Wind farm location problem	Social Multi-Criteria Evaluation
Doukas et al. [24]	Group work of 25 actors from both public and private energy companies	2	Comparison of innovative energy technologies	MCDA [Linguistic ordered weighted averaging (LOWA) and Linguistic weighted operator (LWO)]
GallegoCarrera and Mack [25]	Literature review and Delphi Group process with energy experts	20	Comparison of electricity technologies	MCDA
Ferreira et al. [5]	Literature review, interviews with energy experts and Delphi Group process	4	Comparison of electricity generation technologies	MCDA (AHP)
Beccali et al. [26]	(Not explicit)	3	Comparison of renewable energy technologies	MCDA (ELECTRE III)
Cavallaro and Ciraolo [27]	Data set elaborated by the authors (experimental phase)	5	Wind farm dimensioning problem	MCDA (NAIADE)
Evans et al. [28]	Literature review	10	Comparison of renewable energy technologies	Assumed equal weight for every criteria
Vera and Langlois [29]	Collection of official indicator	4	Construction of a sustainable development indicator dataset	-
Assefa and Frostell [30]	Literature review	3	Sustainability assessment of energy technologies	ORWARE (Swedish technology assessment tool)
Begic and Afgan [31]	Literature review	2	Comparison of electricity generation technologies	MCDA (ASPID – Analysis and Synthesis of Index at Information Deficiency)
Streimikiene and Sarvutyte [32]	Literature review	4	Comparison of electricity generation technologies	Assumed equal weight for every criteria
Alberts [33]	Literature review	2	Evaluation of wind power impacts	Delphi Inquires
Krajnc and Domac [34]	(Not explicit)	3	Socio-economic and environmental impact modeling of biomass utilization	SCORE model
del Río and Burguillo [35]	Data set elaborated by the authors	13	Sustainability assessment of renewable energy projects in rural areas	Elaboration and comparison of case studies (empirical study)
Werner and Schäfer [36]	Literature review	3	Social Sustainability of a specific location solar-power project	Interviews and questionnaires in local community

Last but not least, actually a major issue, as Murray et al. [14] puts it: if social sustainability is about equity, whose notion of equity should prevail?

Although the concept of sustainability is far from being consensual and scientifically exhausted, from this literature review on sustainable development and social sustainability, some basic conclusions may be drawn:

(i) Social sustainability is a multi-dimensioned theme and no satisfactory definition has been made, since none seems to be generally accepted.
(ii) Social sustainability aspects have been changing through time, although, if a hierarchic approach is to be made, "quality of life" should prevail on top.
(iii) Although the matter of time horizon of consideration in sustainability objectives is still not fully established, sustainability definitions always envisage the future generations' wellbeing in the long term.
(iv) Environmental issues can affect the whole planet, so they demand global response; the main example is the Kyoto Protocol, where the scientific community gathered and defined goals in terms of GHG emissions. No parallel exists in the social pillar of sustainability.

1.2. The social dimension in the electricity decision-making process

Economic concerns were the main ones from the beginning of power systems planning when decisions had to be made, so economy tools have obviously been employed for a long time for example for the minimization of cost function, risk analysis or financial project evaluation. More recently, the consensus that emerged from the Kyoto Protocol resulted in goals set for each European country at the level of GHG emissions. Thus, it became urgent for decision makers to impose limits on power systems' emissions and, as a result, it became important to model these emissions. It is clear that, being the environment such a complex system, the

ecologic pillar of the sustainable development is a wider theme than GHG emissions, but we can state that, to some extent, this pillar has also been addressed in a measurable way: GHG emissions function and its institutional restrictions. As stated in the previous chapter the social pillar is traditionally the weakest one; from the literature review, one is led to agree, since less papers address it and no clear institutional restrictions exist.

Table 1 demonstrates a survey of papers published since 2000, aiming to provide the variety of methodologies which supported the selection of social impacts to be included in each study. Table 1, below, indicates also how many impacts are chosen and how they are applied. See Annex I for the complete list of social impacts surveyed.

Nineteen studies were reviewed, with 101 impacts identified in the total. Three of the studies [21,22,29] relied on an approach based on institutional indicators datasets. On the other hand, five included participative methodologies to obtain field information – individual interviews [5,23] or group activities [19,23–25]. The remaining ones either retrieved the required information from the literature; or do not make that information explicit, or the researchers themselves built the dataset.

The choice for the participative methodology highly depends on features of the project, e.g. aspects such as geographical scope, number of participants, budget and time frame must be considered. For a complete review of these participative methodologies see [37]. Although surveys and household interviews are not so common in this phase, as GallegoCarrera and Mack [25] recall, the direct assessment of citizen's personal options may be preferable for some indicators; however this may be difficult to implement due to the frequently large amount of data that must be collected to obtain the intended results. Also Diakoulaki [38] underline that these participative methods are still usually costly and time consuming processes. Besides, it is rather likely that a random citizen may overestimate the possible risks of one technology, as he is not well informed (while believing he is) on technical issues such as the impact of the integration of a certain amount of installed power of a certain technology on the reliability of the whole electrical system. Thus, the population is represented by well-informed groups (NGO, community councilor and energy experts which are aware of the population attitude), in the case of [19,25].

Regarding the number of indicators or criteria chosen on each work, no conclusion can be drawn, since it is fairly independent of the methodology of acquisition of indicators, and depends more on the methodology of their application. For example, AHP relies on pairwise comparisons, so it is particularly suitable for a controlled number of criteria.

From the total 101 impacts identified on the set of papers surveyed, the most referred issues are employment (10 times), change in land cover (8 times), production of toxic chemicals (7 times). Annoyance by noise is mentioned 6 times, income inequalities (5 and investment 4 times).

There are some other impacts that, although not referring to sustainable development at least at an immediate level, can influence decision-making in electricity planning. Three distinct categories seem to emerge: Social Acceptance (9 occurrences), Technical Aspects (3 occurrences) and Risk Factors (11 occurrences). Market aspects are also evoked in some works, although these fall on the economic pillar of sustainable development (for example "market maturity" and "diversity of energy suppliers").

Due to the complexity and conflicting objectives of the thematic involving social concerns, it was found that its application on decision-making falls mostly on MCDA: 12 of the studies use it, although recurring to different techniques, with the exception of Analytic Hierarchic Process (AHP) [5,20]. The literature on MCDA techniques is abundant, and a detailed description of electricity planning with MCDA may be found for example in [39].

Although MCDA techniques are the majority, other well-known policy aiding techniques are also present on the literature, such as Delphi inquiries [33] and local interviews [38] for project acceptance assessment, SWOT Analysis [21] and case studies [35]. There are also other applications that are not so widespread, such as ORWARE [30] and SCORE model [34].

This section provided a description of the most relevant social impacts addressed in the literature, which should be taken into account in subsequent energy decision making models and methods.

Literature on the assessment of the public opinion and social acceptance or opposition to electricity generating projects is much more profuse. Section 2, far from being exhaustive, aims to address this issue presenting a general overview on public attitude towards electricity generation technologies and on methodologies that may be considered for the assessment of public opinion.

2. Public attitude towards electricity generation technologies and related decisions

The possibility to please all the population at the same time in a process like national electricity planning has to be discarded, given the number of citizens affected by an array of impacts and their unequal distribution among the population. The reasons for this unequal distribution are, among others, geographical (for visual and noise amenities) and economic (given the inequality of purchasing power). Formulating a unique optimal plan is unlikely to be a realistic objective and controversial decisions will always have to be taken, as stated in Ferreira [40]. Authors like Upham and Shackley [41] argue that, although a difficult and costly process, the enhancement of local participation in energy planning may lead to more widely acceptable outcome. On the other hand, Alberts [33] states that it can be more productive to consult technical experts than to seek consensus from all stakeholders, as the potential participants may not have sufficient experience or knowledge to effectively contribute to the decision making process.

Given its rising importance, it seems that a significant number of controversies reported in the literature addresses wind power projects (see, for example, [42–44]) where noise, visual and bird strike stand as important concerns. Despite what has been described as a general positive attitude towards renewables [45], some of these projects face resistance, which may delay the completion of the project [27]. However, other forms of energy can also face opposition, some of them involving renewable energy projects, which apparently is a contradiction, given their already mentioned high level of general acceptance. A recent example is the hydropower project in the north of Portugal that faced resistance from a civic movement,[2] opposing themselves to the impacts of the dam, namely submergence of the historical train line, besides visual intrusion and consequences in the agricultural sector. Also, Upreti [46] reported the opposition to a proposal of a combined cycle biomass gasifier in the UK, mainly because of truck movements, pollution and odor. In the case of non-renewable energy projects, nuclear power has been debated for decades. See the recent example of Sjoberg [47], which describes the fear of the Swedish population towards waste from nuclear power plants. Other examples of technologies facing opposition such as carbon capture and storage, and hydrogen are delivered in Section 2.1.

The decentralization of the electricity production in power systems tends to grow with the increasing integration of numerous smaller-scale power plants. These are spread according to the

[2] See http://www.linhadotua.net/ (in Portuguese) for more information.

distribution of the renewable resources; therefore, getting closer to the consumer, possibly present in his daily life landscape [48]. The term NIMBY (acronym for Not In My BackYard, popularized in the 80's by the British politician Nicholas Ridley) classifies the attitude of citizens who generally agree with a given project (not necessarily related to energy), but oppose it if it is to be done in their "backyard". This term has been present in the literature associated with wind power since the 80's and is often regarded as common sense [49].

Wolsink [49] contextualizes NIMBYism as game theory for economists and social dilemma for psychologists: the prisoner's dilemma. The consequence of the prisoners' dilemma is that, although the whole society would be better off if the public good (in that case, wind power) was produced, everyone tries to minimize private costs (in that case, wind power's negative impacts) and this stimulates the so-called free rider behavior: blocking the development of wind farms in their vicinity, which dominates the social best solution.

Other papers reviewed in [50] tested the NIMBYism hypothesis of wind farms and concluded that they do not explain all the resistance that projects faced. In line with this Maruyama et al. [51] argued that community-owned wind programs they reviewed in their work (referring to Japanese examples) seem to move away from the NIMBY attitude. In fact, institutional factors may be more important than NIMBYism, and building institutional capital should improve rates of wind power implementation [49]. Institutional capital implies knowledge resources, relational resources and capacity for mobilization. Gamboa and Munda [23] mention an example in Catalonia, where wind turbines siting was a successful task given the affected population's participation in the decision-making process. The same paper also proved that municipalities' income and job creation favor projects acceptance. Kaldellis [42] research put in evidence the conservative nature of people living in a Greek island near a wind farm development, demonstrating some public opinion divided or mostly against. The author also pointed out other parameters that negatively affected public perception, such as the great amount of concentration of wind turbines. The author believes that additional public information regarding wind energy could improve the levels of acceptance.

Loo [52] even coined the NIMBY's opposite as PIMBY (Please In My BackYard) for the cases in which revenues for the development increase the acceptance of a particular project. Given the variety of opinions in the literature, one may conclude that the validity of NIMBYism is still an open problem.

2.1. Methodologies to address the social dimension of electricity planning

The assessment of the public opinion, social acceptance or social opposition to projects falls in the social sciences domain. In this area, the research methodologies are frequently grouped in qualitative and quantitative approaches. "Qualitative, naturalistic approach is used when observing and interpreting reality with the aim of developing a theory that will explain what was experienced" whereas "the quantitative approach is used when one begins with a theory (or hypothesis) and tests for confirmation or disconfirmation of that hypothesis" [53]. The authors argue that, depending on the research, both types of methods can be used on their own, but also combined. Recent examples of both types of methodologies applied to particular cases in the scope of electricity planning are described in this section.

Quantitative methodologies appear to be predominant in the published literature of public perception of renewable energy. Ellis et al. [54] reviewed 45 public opinion and attitude surveys made in the UK and Ireland, from which 78% were quantitative, 18% qualitative and 4% mixed. Devine-Wright [55] collected references for the USA, Canada, Denmark, Sweden, Germany and Netherlands and corroborated that the literature in western developed countries is mostly empirical, and uses quantitative survey.

A set of common methodologies, representative of the whole literature that addresses public perception of electricity generation technologies is presented.

Surveys are a methodology that uses, generally, closed-ended questions (example: "do you know your height?"), although they can include focused, short-answer questions (example: "what is your height?") and multiple choice (example: "from the following list of issues, choose the two which are more important in your opinion"). In all these cases, surveys are considered a quantitative methodology. However, surveys can be open-ended, which implies that space is given to the respondent's own words; in this case, the information obtained is qualitative.

A clear advantage of close-ended surveys' use is the statistical treatment of data collected among large amounts of people, from which it is possible to derive patterns regarding behaviors according to respondents' age, location and social class, among others. According to the sample size it is possible to determine validity and statistical significance of a survey.

As Devine-Wright [56] states, these studies tend to be successful in describing one-off snapshots of public views, given their statistical significance; but detailed explanations of their causes remain obscure, therefore are useless to build theory. The author also believes that disciplines such as psychology can be helpful in tackling this issue providing alternative frameworks for questionnaire surveys, demonstrating the necessary interdisciplinary of future research teams. In spite the aforementioned shortcomings in explanations, the general picture taken by the Eurobarometer [45] survey include perceptions at various degrees: importance of the theme ("EU citizens rate energy issues far below unemployment, crime and healthcare systems"), level of knowledge ("Europeans appear to be knowledgeable of the level of energy dependence"), fears ("appear not to fear great societal changes, such as the rationing of energy consumption or not being able to buy a car") and hopes ("45% consider that their government should make guaranteeing low energy prices a top priority in their energy prices"). Group distinctions are also perceptible ("males, the highly educated and those in managerial position seem to be more knowledgeable of energy issues").

Surveys size can vary: while the Eurobarometer survey covers 15 topics, Wolsink [49] designed a survey to test the NIMBY's hypothesis, with only five social dilemmas statements, aiming to conclude that the concept might be insufficient to explain opposition to wind power projects. In his case there were 725 respondents, which were residents near three wind farms. The surveys were close-ended ("support" or "reject") and were the following: "Only turbines here if sited elsewhere too", "Turb's create costs, benefits unlikely, uncertain", "Preference for other sites, elsewhere", "We bear costs, elsewhere they don't accept" and "Benefits only for the electricity utilities". The surveys responses were collected during interviews.

Ansolabehere and Konisky [57] also used surveys to perform a comparison of public perception on types of power plants: coal, natural gas, nuclear and wind farm. They assessed perceptions about siting the power plant near the respondents' home, perceived environmental harm and perceived cost.

Surveys are often used in recent literature addressing acceptance of promising forms of electricity generation; see for example, Wolsink [58] on near shore wind, Warren et al. [59] on tidal energy (this study was complemented with focus groups, see later in this chapter for more information on this methodology), Itaoka et al. [60] on carbon capture and storage, Achterberg et al. [61] on hydrogen technology, among others.

Within qualitative methodologies, the Q methodology, according to Brown [62], provides a framework for systematic study

of subjectivity, personal viewpoints, beliefs and attitude. Its special feature is the aim of mitigating researcher bias. Ellis et al. [54] used this methodology as they claim that the literature often assumes NIMBY-ism as a valid theory, and they wanted to test it in one year case-study of an offshore wind farm in Northern Ireland. This way, instead of capturing information existing in a whole population, it rather focuses on a selected sample of subjects. The authors analyzed texts related to public debate, both for and against wind power in general, along with government policy documents and public debate around the specific offshore wind farm. Put simply, the objective of the whole methodology was to extract 50 statements that summarize viewpoints, which participants were to sort according to their priorities. The result of this research project could deliver information such as "those who oppose the project ask whether decisions are being taken for the right reasons and question the notion that science, policy makers and economists are necessarily working exclusively for the public good", and that "there is a fundamental disagreement over the value of wind energy and its ability to make a major contribution to the country's energy needs", among others. Along with the 50 statements, 8 idealized profiles ("factors") were created and it was possible to analyze how much an interviewee fell in which factor.

Wolsink and Breukers [63] used also Q-methodology to identify different perspectives on wind power, among stakeholders of three different countries. The authors identified four different factors, one against wind power implementation and three fundamentally supportive but for different reasons. Controversial issues were found to be landscape values, participation in the project planning, local decision-making, financial participation and the role of local authorities. The respondents were stakeholders from conventional energy sector, private wind project developers, cooperatives and citizen projects, wind power and renewable branches, environmentalists and landscape preservation organizations, anti-wind power groups, researchers and governmental bodies ranging from local to national bodies.

Among qualitative methodologies, interviews are quite popular, especially with experts. Huijts et al. [64] assess perceptions on carbon sequestration and storage, in two distinct phases, which involved, first, well-informed groups (industrial, governmental, energy companies, NGO) and, later, general public. In the first phase, stakeholders and experts were interviewed, after which they had group discussions; finally, the second phase was the distribution of 103 surveys in two different communities. The main conclusions presented in this work were that all the professional actors showed interest in the technology, while the general public appears to have little knowledge and little desire for more information, therefore trust (mainly on the NGO) the key for success. The main difference between surveys and interviews stands, thus, in the quality of information: while the surveys had to be representative (103 surveys handled to the population), it would have been time-consuming, costly and probably useless to use interviews, given the little knowledge presented by the general population, which would add no more information than the one presented in the surveys' responses. On the other hand, the interviews with the four well-informed groups provided information on particularly important issues (costs, technical, legal possibilities, risks), which was precisely the information that the authors were looking for. Therefore, we might emphasize interviews as particularly useful for exploratory phases.

Jobert et al. [50] used five German and French wind park case-studies to evaluate how policy frameworks influence their local acceptance. For each case, eleven and fifteen semi-structured interviews of one to two hours were carried among local actors such as city-council members, journalists, project planners, regional representatives and spokespersons of local associations. Semi-structured interviews are usually based on a guide prepared in advance with questions taking into account the information the researcher is looking for. Contrarily to surveys or structured interviews, the researcher is free to further explore some themes that arise during the conversation. The authors found it particularly helpful in case-study context, as is the main aim of the paper.

To assess public perceptions on community-based energy projects in the UK, Rogers et al. [65] used both questionnaire surveys and semi-structured interviews. The data was collected among rural households: the 46 questionnaires (administrated face to face or by telephone) were used to collect both quantitative and qualitative data, from the closed and open questions, respectively; whereas the nine semi-structured interviews collected qualitative data, among households and businessmen. The interviewees had contrasting views on the theme, and that choice has been made on purpose. The authors argue that the advantage of doing interviews in this case was the possibility to explore other themes related to the main research question.

Gross [43] explored public perceptions regarding procedural justice on a wind farm pilot study. Having been argued that the involvement of community in the process can increase the acceptance of renewable energy projects, the aim of the study was to propose a community fairness framework, with the intent to aid community consultation and increase social acceptance levels. Twelve semi-structured interviews were made, therefore the key informants selection represented a crucial phase of the methodology implementation. In order to select individuals able to provide collective and important viewpoints, the authors resourced to snowball or networking effect.

Focus groups is another qualitative research methodology, in which a group of people is asked about perceptions or attitudes towards a certain question, and are free to discuss it. The reviewed papers showed the flexibility of focus groups, since they have been successfully used on their own, or along with other qualitative or quantitative methodologies.

For the assessment of public perception of carbon capture and sequestration, the US Department of Energy used focus groups in five communities of three different regions [66]. The study aimed to derive patterns of commonalities and divergence between the regions. In order to be properly effective as a comparative study between the locations, the protocol was built by three teams of researchers, one of each region. This way, besides seven common topics, intrinsic questions regarding the specific historical, economic and social profile of each region could be included. Also, a major issue was the choice of the communities to study. This choice was based on the prospect technology installation, so it ranged between very probable and improbable places to do it. Besides inter-regional general attitude comparison, socioeconomic status was taken into account. The authors argue that, although no statistical significance could be inferred, the focus groups methodology flexibility was a key factor to the success of the study.

Also, Gough and Shackley [67] used focus groups but combined with surveys to assess carbon capture and sequestration acceptance in the UK. The surveys were used after the focus groups process implementation, and were specifically designed according to these focus groups findings.

More recently, Flynn et al. [68] also resourced focus groups to assess public attitude towards hydrogen, in three regions within the UK which have already installed hydrogen facilities or had plans for developing them. The process consisted in two phases: nine groups in the first and seven in the second, ranging from three to thirteen elements possessing varied socioeconomic backgrounds. The first phase was more geared towards general information on energy and environmental issues. The second phase was focused in hydrogen technologies. The continuation of the project (not treated in that paper) was a series of citizen panels, carried out to engage

community in a participative and deliberative process about alternative scenarios for hydrogen energy.

3. Conclusion and future work

The present work consisted in a review of the literature with the potential to aid the elaboration of a methodology, intended to support the explicit inclusion of the social pillar of sustainable development while planning the expansion of the generation capacity of power systems. The literature review covers fields within engineering and social sciences disciplines. As a major conclusion, interdisciplinary is seen as a tendency in sustainability issues.

The underlying theory of social sustainability was first reviewed. Theoretically, social sustainability appears as a fuzzy concept, although it can, in a very general way, be associated with the quality of life of our society (and its inequalities, health and employment issues) now and in the future.

Chapter 2 was written with the purpose of surveying a list of the most common social impacts associated with electricity generation technologies, as well as the applications in which these impacts are involved. For planning purposes and technology comparison, Multi-Criteria Decision Methodologies are the most frequent application of these indicators and often imply expert participation. The inclusion of the social dimension in power planning still seems to be an open problem, whose roots are the incommensurability of the social dimension of sustainable development. A simple example: renewable energy technologies may have better performances on health and employment issues than the conventional technologies, but if they are more expensive, will they lead to inequalities in the society? From the survey of indicators present on the literature, employment is by far the most cited, which coincides with citizen's worries about life in general, at least in the EU [45].

A set of methodologies for assessment of public and experts opinion on electricity generation technologies are reviewed. Papers presented in this review concluded that citizens' fear about technologies, often backed by lack of knowledge, brings up the need to build trust in institutions [49,64]. Also, the collaboration with both citizens and their representation institutions (being non-governmental organizations the preferred) can increase success in decision-making.

Upon the literature review, plans are now drawn for future work. A mixed methodology resourcing qualitative and quantitative tools is envisaged. Collaboration with experts in power systems will most likely assume the form of semi-structured interviews. This methodology appears appropriate since its openness will enable the possibility to draw guidelines. Questions like "which generation technologies are available within the next 10 years?" "how much installed power is technically feasible for each of them?", among others should be addressed. It will enable the possibility to retrieve information which appear significant in the eyes of the expert and not present in the guidelines, or explore further some themes.

The list of the social impacts to be considered and further explored is also expected to contribute for a multi-criteria decision methodology to be used with the experts, aiming to rank the technologies, projects and scenarios according to their social sustainability performance.

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Annex I.

Survey of social impacts mentioned by the papers presented in Table 1.

Number	Reference	Social impact
1	(Kowalski, Stagl et al. 2009) [19]	Regional self-determinancy
2	Ibid.	Social cohesion
3	Ibid.	Social justice
4	Ibid.	Quality of landscape
5	Ibid.	Noise
6	Kahraman and Kaya [20]	Compatibility with the national energy policy objectives
7	Ibid.	Political acceptance
8	Ibid.	Social acceptance
9	Ibid.	Labour impact
10	Karakosta et al. [21]	Contribution to the net number of employed persons as a result of project implementation
11	Ibid.	Improvement in the quality of life of weak populations
12	Roth et al. [22]	Physical security
13	Ibid.	Political stability and legitimacy
14	Ibid.	Social development
15	Ibid.	Impacts on quality of landscape & residential areas
16	Ibid.	Impacts on human health
17	Ibid.	social components of risks
18	Gamboa and Munda [23]	Municipalities income
19	Ibid.	Number of jobs
20	Ibid.	Visual impacts
21	Ibid.	Forest lost
22	Ibid.	Noise annoyance
23	Ibid.	Avoided CO_2 emissions
24	Doukas et al. [24]	Contribution to employment opportunities' creation
25	Ibid.	Contribution to regional development
26	GallegoCarrera and Mack [25]	System availability on demand
27	Ibid.	Diversity of energy suppliers
28	Ibid.	Reserves and resources
29	Ibid.	Waste management
30	Ibid.	Flexibility to respond to market signals
31	Ibid.	Flexibility to incorporate technical developments
32	Ibid.	Potential of conflicts induced by energy systems
33	Ibid.	Willingness to act (mobilization potential)
34	Ibid.	Reliance on participative decision-making processes
35	Ibid.	Citizens acceptance of the system
36	Ibid.	Perceived risk characteristics for accidents
37	Ibid.	Perceived risk characteristics for normal operation
38	Ibid.	Trust in risk management
39	Ibid.	Health effects from normal operation
40	Ibid.	Health effects from accidents
41	Ibid.	Terrorists threat – potential for attack
42	Ibid.	Effects on a successful assault
43	Ibid.	Equitable life conditions
44	Ibid.	Perception of the fairness of risks
45	Ibid.	Effects on the quality of landscape area
46	Ferreira et al. [5]	Noiseimpact
47	Ibid.	Impact on birds and wildlife
48	Ibid.	Visual impact
49	Ibid.	Social acceptance
50	Beccali et al. [26]	Labour impact
51	Ibid.	Market maturity
52		

Number	Reference	Social impact
	Ibid.	Compatibility with political, legislative and administrative situation
53	Cavallaro and Ciraolo [27]	Social acceptance
54	Ibid.	Impact on ecossystems
55	Ibid.	Acousticnoise
56	Ibid.	Visual impact
57	Ibid.	CO_2 emissions avoided
58	Evans et al. [28]	Toxins
59	Ibid.	Visual
60	Ibid.	Birdstrike
61	Ibid.	Noise
62	Ibid.	Displacement
63	Ibid.	Agricultural
64	Ibid.	River damage
65	Ibid.	Seismic activity
66	Ibid.	Odour
67	Ibid.	Pollution
68	Vera and Langlois [29]	Accessibility of electricity
69	Ibid.	Affordability of electricity
70	Ibid.	Disparities
71	Ibid.	Health/safety
72	Assefa and Frostell [30]	Knorwledge
73	Ibid.	Perception
74	Ibid.	Fear
75	Begic and Afgan [31]	Job
76	Ibid.	Diversity
77	Streimikiene and Sarvutyte [32]	Technology-specific job opportunities
78	Ibid.	Food safety risk
79	Ibid.	Fatal accidents from past experience
80	Ibid.	Severe accidents perceived in future
81	Alberts [33]	Noise
82	Ibid.	Wild life
83	Krajnc and Domac [34]	Possible impact on regional unemployment
84	Ibid.	Avoided costs of unemployment
85	Ibid.	Self-sufficiency in electricity production
86	del Río and Burguillo [35]	Impactonemployment
87	Ibid.	Demographical impacts
88	Ibid.	Energy impacts
89	Ibid.	Educational impacts
90	Ibid.	Impacts on the productive diversification of the area
91	Ibid.	Integration in the local economy (use of local resources)
92	Ibid.	Social cohesion and human development
93	Ibid.	Income distribution and impact on poverty
94	Ibid.	other economic benefits (unrelated to employment)
95	Ibid.	Involvement of local actors and perception of the benefits of the project
96	Ibid.	Impact on tourism
97	Ibid.	Creation of a local industry
98	Ibid.	impact on the municipal budget
99	Werner and Schäfer [36]	Water quality and quantity
100	Ibid.	Human resources
101	Ibid.	Social acceptance

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